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STRATEGY FOR ADOPTING AND IMPLEMENTING GIS TECHNOLOGY IN REGION 8

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EXECUTIVE SUMMARY

This report gives a general background on GIS technology, identifies the opportunities for implementation, digitizing, database design, training and technology transfer. It also outlines several issues for further study, presents a study plan for a demonstration project, an implementation plan for the George Washington NF and an Action Plan for the Region. Options are given and a preferred one is suggested for each phase of GIS technology implementation. Recommendations are made for actions in FY 1985-86.

It is recommended that no decision be made at this time on which specific GIS should be implemented Regionwide. This can be done after the results of the WO Workload Analyses and benchmarking and the Region's demonstration project are evaluated. The number one priority is the approval and implementation of a demonstration project to evaluate the ARC/INFO GIS. This project, which would be conducted on the Dry River District, George Washington NF would evaluate the logistical problems which might be expected in a GIS implementation, to evaluate database design, obtain realistic benefit/cost estimates, determine if specific map products and tabular data can be produced, and whether this system has analysis capabilities necessary for the Forest Service.

ARC/INFO is the current "state of the art" GIS distributed by Environmental Systems Research Institute. It has performed very well in evaluations and has been operationally implemented by many state and municipal agencies, private concerns, and foreign governments. The Forest Service has not evaluated it. ARC/INFO has a fully integrated relational database manager, processes data in arc/node form, operates on Data General Computers which in turn makes it compatible with the Forest Service telecommunications system.

Another GIS, which is currently being evaluated and implemented by a number of federal and state agencies, is MOSS (Map overlay and statistical system). The Forest Service is evaluating this system in Regions 6 and 9. Forest Pest Management is evaluating it in Regions 1, 2 and 9. MOSS does not have a relational database manager, does not process data in Arc/node form, and does not possess the complete analyses capabilities needed by the Forest Service.

This report also discusses the need for development of a comprehensive database design. GIS technology should be decentralized and implemented at the SO and District levels. Some staffing shifts may be necessary at the SO and District levels to support a GIS, but no new positions will be required at this time except for a full-time GIS specialist in the RO. This individual would facilitate GIS technology implementation, coordinate database design, develop applications and provide training in cooperation with specialists in Engineering, Management Systems and other Staff Units. Finally, an awareness program for GIS should be developed and conducted throughout the Region during FY 1985-86.

I. INTRODUCTION

A. Background

The Forest Service has been considering the opportunities to use Geographic Information Systems (GIS) for many years. Presently, this technology is used by most major paper companies and by a variety of state and federal land management agencies. Geographic Information Systems have, in fact, been used in many project level efforts in the development of land management plans on a number of National Forests. National Forests maps have been digitized, both within the Forest Service and by consultants. These efforts, however, have yielded data in a variety of formats with inconsistent standards and organization. In most cases, the data was sufficient for a one-time application, but was not designed to become part of an overall data base. Furthermore, a data analysis capability has seldom been available on-site for use by field level managers.

The shortcomings of the situation described are obvious. The real payoff from GIS technology can only be fully realized when it is in the hands of the field level manager. Furthermore, the investment in digitized maps is optimized when consistent standards of quality, format and organization are maintained. The ability to aggregate, summarize, synthesize and pass data up to the Regional and National levels, can only occur if the database for each District and Forest is consistent.

Within Region 8, maps have been digitized in several different formats requiring different computer programs for analysis. Some of this data has been collected in polygon form and some in cellular (raster) form. Some of the data conforms to standard basic formats that can be "read" by several GIS systems. Some can only be processed by specialized proprietary software packages; many which do not operate on computers owned by the Forest Service. Thus, is the situation in the Region, and therein lies the reason for this report, a "Strategy for Adopting and Implementing GIS Technology in Region 8."

The need for a comprehensive organized plan for implementing GIS technology is obvious. Selection of a suitable GIS software system that includes the analysis capabilities, given the expected applications, must be made. Thus, several options are presented. The options for implementation, considering training needs, a plan for digitizing and updating the data base are included. Finally, a plan for demonstrating the proposed system is given, which logically is the first step toward implementation.

B. Approach for Evaluating GIS Opportunities

The procedure taken to develop a strategy for Region 8 to implement GIS technology involved five basic steps. First, an inventory of current and past GIS activities was made. This inventory included digitizing activities, map products that had been produced, an assessment of the hardware used and available for future use in processing GIS data, GIS software, and finally assessing the current level of awareness about GIS technology among the professional staffs within the Region. Second, a comprehensive review and an empirical analysis was made of all available GIS systems, both in the public and private sectors. Third, an assessment was made of the information processing needs for the Forests and RO Units within the Region. The fourth activity involved considering the level to which the technology and related functions should be decentralized. Finally, a recommended plan for implementing and transferring the technology was developed, considering the options available for the Region.

This report is only the first step in developing the strategy for implementing a GIS. Other subsequent reports will address the identified technical issues and concerns. Collectively, these reports plus the results of the demonstration project will guide the Region's administrators through the implementation process.

C. GIS Terminology

Several terms will be used in this report to describe various GIS functions which need to be defined.

1. Geographic Information System - A Geographic Information System (GIS) is essentially a software package used to store, organize, retrieve, and analyze resource data according to spacial relationships. The information is stored in a database format and organized according to its spacial location. In this sense it is a symbolic representation (an abstraction) of what is actually on the ground. Once stored, the data can be retrieved and analyzed in formats that address specific management problems or options. Through a GIS, the interpretation of spacial relationships can be automated, which in turn simplifies the use of this otherwise diverse information.

2. Relational Database Manager - A relational database manager facilitates efficient handling of the two generic classes of spatial data: cartographic data describing the location and topology of point, line and polygon features; and attribute data describing the characteristics of these features. A fully relational Data Base Management System (DBMS) allows the user to easily create and manage georeferenced tables of statistical or thematic data, including real and integer numbers, dates, text and references to tables of interpretive data or graphic symbols. The DBMS also allows the user to easily associate and interrelate information from several files by matching selected codes which are common to each field. For example, if soil type is associated with each polygon, it can be matched with a file containing interpretations for each soil type, thus providing a link between the polygon and the interpretations.

3. Raster Data - Raster data is digital map data in a grid or cellular format. The cells can be coded to represent a point; strung out, end-to-end, to represent a line, or when considered individually or collectively with neighboring cells, as polygons. The cell size can be large or small, depending upon the application. The larger the cells, the more "jagged" the edges for polygon boundaries, or road lines, etc.

4. Vector Data - Vector data is represented by a series of finely spaced coordinate points (x,y), with a straight line connecting the points. If the points are very close together, curved lines and polygon boundaries have a continuous smooth appearance.

5. Arc/node Data - Arc/node data is recorded as a series of nodes, with a coordinate pair, and the function describing the line connecting it to the next node. The left and right polygon number or attribute is stored for each arc, known as the topology. In this way each unique line is only stored once, even though the arch may be both a road and a timber stand boundary. This minimizes data storage and permits rapid "arc/node" processing. This is the best and most efficient way of digitizing maps.

6. Attribute - Characteristics of a site's condition or quality, i.e., pine, size class, age class, etc.

7. Digitize, Digitizer - The process of using the digitizer to produce computerized representations of maps and aerial photography. A digitizer is an instrument that transforms maps into a computerized form. Computer programs can then use the data to calculate areas or produce plotted maps.

D. Available GIS Systems

1. ARC/INFO

ARC/INFO is a proprietary GIS system marketed by Environmental Systems Research Institute (ESRI) and is widely accepted as the current "state of the art." ARC is the GIS and INFO is the database manager. It has a 32 bit program and operates on Data General and Prime minicomputers. It is one of very few systems that has a fully integrated relational database manager and has an expansive attribute handling capability. ARC/INFO processes vector and raster data and can process the vector data directly in its arc/node form, rather than in polygon form. Therefore, it rapidly processes overlays, and with less data redundancy. This digitizing software automatically edits the digitized map, adds topological data to the arc segments, weeds out unnecessary coordinate points, and calculates area, perimeter and polygon centroids. ARC/INFO can accept and automatically convert data from other cartographic formats, including nontopological graphic data from scanners, coordinate data from a photogrammetric work station, Landsat satellite data, polygon data, U.S. Geological Survey Digital Line Graphs, and many other types of data.

For editing of cartographic data, software is used to verify the correctness of all geometric and topological data. Graphic displays are generated with graphic symbols illustrating any errors in the database, such as undershoots, overshoots, knots, missing arcs, and duplicate arcs. These may be corrected using both procedures or the interactive graphic editor. This same editor may also be used to add, delete or modify older data files contained in the database.

For attribute verification and editing, ARC/INFO contains automatic arithmetic and logical operations. These can be set up by the user to perform cross-field checking, range checking, attribute consistency checks and absolute value checking. A full-screen editor allows for easy user modification.

Polygon coordinate and attribute updating may also be performed automatically using a "paste over" technique built into the polygon overlay software. This technique provides the user with an easy method for digitizing new polygon areas where changes have occurred (i.e., cuts of timber) and overlaying the update directly into the database. The software readjusts cartographic and attribute data with a fully automated procedure. This procedure is used to carry out ongoing accounting and reporting of geographic transactions in both a graphic and tabular form (i.e., timber cutting, land use changes, etc.).

ARC/INFO has the following capabilities for management of survey data:

Entry/recording, edit and adjustment of survey traverse data using input such as field notes, subdivision maps, tentative parcel maps and legal descriptions.

Fully automatic conversion of traverse data from digitized coordinates (i.e. bearings of field angles and distances from State Plane coordinates)

Adaptable procedures for entry and standard subdivison of Government Land Office (GLO) section records.

For large cartographic data files such as those covering a region, state or country, ARC/INFO allows the user to employ a unique spatial library system for efficient insertion, storage, and extraction of geographic data. This system uses an internal spatial indexing system for partitioning geographic data into rectangular or other shaped regions called "tiles." These user defined tiles are similar to map modules and may contain any number of geographic data sets with information describing the location and characteristics of this data. The indexing structure facilitates rapid and fully automatic insertion and extraction of data using an access procedure which is independent of the data. The system also allows the user to summarize detailed map data by the index tile areas. This summary data can be manipulated by all of the various ARC/INFO software. The map insertion function automatically partitions and indexes each map file according to a tile structure designed by the user, without regard to size or scale of files. For extraction, the user specified a polygon coordinate window, tile number, or other geographic area partition along with the map variables of interest. The system then extracts the data of interest. Map joining software can automatically connect the tiles into a "full coverage" data file for subsequent analysis and display.

Network Analysis is optional software for interactive network analysis and simulation. It is used for vehicle routing, optimum facilities siting, polygon redistricting, route selection, and time/distance flow analysis. A general purpose query capability allows the user to arbitrarily specify map variables of interest in a selected coordinate region of the database and to search, extract, manipulate, display, list and recreate a subset of the database for specialized analysis and display. Tabular analysis software includes a full query and manipulation capability for conducting arithmetic and logical operations on the attribute database. This capability is linked to an interactive report generator for design and output of user formatted tabular listings. Report design options include full row and column layout, titling, totaling and subtotaling. ARC/INFO is supported through educational programs, extensive documentation, technical consultation and user group conferences. The manufacturers of ARC/INFO also provide a range of complementary services including database design, mapping, digitizing, and related application consulting.

2. Map Overlay and Statistical System (MOSS)

MOSS is a public domain GIS composed of a set of software for encoding, transformatting, analyzing and displaying map and other geo-based information. Originally developed by the Western Energy and Land Use Team of the U.S. Fish and Wildlife Service, the GIS has since been adopted by the Bureau of Land Management, Bureau of Indian Affairs, and many State agencies. Work was initiated on MOSS in 1977 when a detailed user needs assessment was performed. Since then a number of changes and enhancements have been made to the software. These enhancements and changes are continuing.

MOSS is composed of three components: Analytical Mapping System (AMS) for digital data-entry; Map Overlay and Statistical System (MOSS including MAPS) for data processing, analysis, and display; and Cartographic Output System (COS) for enhanced cartographic plotting. It has been designed to allow users to retrieve, analyze and display maps and other spatial data stored in the system. Map data may be captured in two formats: vector, and cell or raster. Vector data consists of a series of (x,y) coordinates forming points, lines or polygons. Each feature in a vector may be assigned an identifying attribute based on its characteristics. Cell data consist of a regular grid pattern in which each cell in the grid is assigned an identifying value based on its characteristics. Cell data may be created from vector data, a process called rasterizing. Because information from vector maps is generalized into cells by this conversion, vector maps may not be created from cell maps. Accuracy, resolution, storage, and processing of cell maps is directly related to grid-cell size. Some data, e.g., Landsat satellite imagery, originate in raster format. The digitizing software captures the data in an arc/node format, but the data is formed into polygons before any processing is done.

In MOSS, cell maps are handled by software referred to as the MAPS sub-system. Map format, command syntax, and data retrieval characteristics are different, therefore, vector processing capabilities will be referred to as MOSS whereas raster capabilities will be referred to as MAPS. Although MOSS and MAPS may be accessed together, they may also act as stand-alone systems. Limited raster processing capabilities exist within MOSS. Note that vector maps and data used in MOSS may be used in MAPS, but cell data used or created in MAPS may not be used in MOSS. Choice of data format will largely depend on the final intended use of data. In general, vector maps are preferred for high precision cartographic analysis and aesthetically pleasing cartographic output whereas cell maps are preferred for complex cartographic modeling procedures.

MOSS operates on the Data General MV 4000 and 8000 minicomputers and the DG 20 microcomputer. It operates in a 16 bit environment which is slower than 32 bit systems. It doesn't have a relational database manager and has limited attribute handling capabilities. There are plans for other government agencies to fund major improvements and upgrades over the next several years. The Fish & Wildlife Service sponsors many training sessions for the use of MOSS and there are annual Users Group meetings.

3. INTERGRAPH

The Intergraph system was originally designed as a computer aided design/computer mapping system. It was marketed for engineering and architectural application. It is very "user friendly," interactive and has an outstanding plotting capability. The system records information in a dual fully integrated relational database structure. It runs on the Digital Equipment Corporation's VAX 11/730, 11/751 and 11/780 minicomputers. The Intergraph system is being used for handling natural resource data by the U. S. Geologic Survey, Tennessee Valley Authority and St. Regis Paper Company.

4. SYNERCOM

Synercom's Environmental Mapping Information System was designed to provide the features and functions of both a relational database management system and a geographic information system. It is essentially an enhanced version of the Harvard Computer Graphics Laboratory's ODYSSEY software. The digital data is captured and analyzed in an arc/node format. The data is efficiently stored by "partitioning" into user defined geographic areas called facets, across the continuous domain of the database. The SYNERCOM system operates on VAX computers and is capable of reading data in all standard formats.

5. COMARC

The COMARC system is a proprietary turnkey GIS system that was very popular with forest product companies in the past. However, many of these systems are being dropped due to the lack of system and user support given by the manufacturer. There have been many dissatisfied users of this system because of certain business practices of the company. COMARC operates on Data General minicomputers. It does not have a relational database manager. This system can process raster or vector data and has a very easy to use and efficient digitizing software package. However, the format of all data digitized with the COMARC system is proprietary. This precludes passing digital data to other government, state or private users who do not own a COMARC software license as well.

6. GEOBASED

GEOBASED is a proprietary, turnkey GIS that evolved as a spin-off from the COMARC system. It only operates on a DEC computer. This system has a tabular data managment package, but not an integrated relational database management system. The data is captured and processed in an arc/node format. It has a good attribute handling capability. Also, this system has an efficient digitizing and editing capability. However, the data format is proprietary, which limits data exchange opportunities.

7. AGIS/GRAM

AGIS/GRAM is a very new experimental proprietary system that has not received widespread use. The hexagon cellular data structure is unique. Due to the mathematical properties of hexagonal matrix overlays and spatial functions may prove to operate very efficiently. However, this system does not have a relational database manager. It may be difficult or impossible to reformat data from standard sources like digital elevation data, and data from other agencies into the AGIS/GRAM format and conversely for others to use AGIS/GRAM data.

8. BAUSCH & LOMB

The Bausch and Lomb Resource Measurement System (RMS) is not a GIS, but rather a digital planimeter. This system operates on an APPLE computer and the software is written in BASIC. The format of the digitized data produced with the RMS is not compatible with other major GIS systems and is not in arc/node format. It is not presently capable of reading digital elevation data or other data in standardized formats.

9. ERDAS

The Earth Resources Data Analysis System (ERDAS) is basically a turnkey image processing and computer mapping system. While the ERDAS system is capable of merging, storing and displaying a variety of digital resource data it does not have the primary analysis capabilities needed for a comprehensive GIS. Data is not digitized in an arc/node format and it does not have a relational database management system. It has only a limited attribute handling capability.

10. IDIMS

Interactive Digital Image Manipulation System (IDIMS) is basically an image processing system with a very limited GIS capability. The digitizing software, the Geographic Entry System (GES) does capture data in an arc/node form but is tedious to use and is not very efficient. A computer program has been written to convert data from GES format to a MOSS compatible format. However, GES format is not in common use and the IDIMS system does not operate on Data General computers.

11. INTERNATIONAL IMAGING SYSTEMS

International Imaging Systems (I^2S) has been marketing image processing systems for many years. In 1984, I^2S formed an agreement with Geobased to integrate their two systems to form a GIS with an image processing capability. Thus the I^2S system's GIS capabilities are the same as those given on Geobased, above.

II. OPTIONS FOR DATABASE DESIGN AND DEVELOPMENT

A. Introduction

A recent database design study conducted for the Tongas National Forest[1] in Alaska discusses the current state of their natural resource data. Portions of their report are given below, since the same conditions exist in Region 8:

> Forest Service natural resource data and information currently exist in a broad variety of forms, including inconsistent classification schemes and formats, scales and resolutions. Among these data, there is a lack of correlation and consistency among district and area offices, between different functional data sets, and within particular data bases or types. Some of these data are currently in automated form, while many are not.
>
> Forest Service professional staff in the various functional areas are familiar with the current range of data resources which are available; these professionals, in many cases, were the original creators of these data inventories, and are also the key users of these data. Such familiarity allows the current disparate array of data resources to be utilized by those who created it, but presents problems related to access and use for other users of the data.
>
> An important benefit of [maintaining status quo] is that no new costs would be associated with the maintenance of existing data resources. Furthermore, to varying degrees, the current sets of data do respond to the identified tasks which Forest Service staff must carry out. It is important to recall, however, the extensive labor costs currently invested in creating and using existing natural resource data by Forest Service staff.
>
> The manual format of existing data, ...presents many procedural limitations. First, the manual format makes difficult the aggregation of cartographic and tabular data sets for reporting data to the SO, RO and WO levels. Under automated data base design options, such needs for data aggregation will be better facilitated. Second, data and systems will not support the linkage of existing tabular data (either manual or automated) with manual maps for producing interpretive map products..... Third and finally, in existing manual maps, there is little correlation or integration of related resource boundaries, such as timber types and soil types. This presents problems in the preparation and analysis of manually prepared interpretive maps.

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[1] Preliminary Data Base and Conceptual System Design Report Tongass National Forest (Ketchikan and Stikine Areas) Natural Resource Management Information Study, Contract No. 53-0109-4-00161. June 1984, p. III -54, 55. ESRI Information Study.

It is clear from the above that an automated data base, properly designed, holds many advantages over a manual system. It is not appropriate in this report to consider the details of the "best" specific data structure, etc. that would be needed. This would be the topic of a subsequent report when a decision is made to implement GIS technology and build a digital data base. The options given below consider the opportunities for standardization, format exchange compatibilities, and the criteria for justifying acquisition of costly digital data. The specifics for digitizing and a time frame for data capture are given in Section IV.

B. Options

Option 1:

The Region should wait for the W.O. to establish national standards and a comprehensive database design, and then adopt them for use.

Option 2:

The Region should develop and establish standards and a database design for use by all its Forests.

Option 3:

Each individual Forest, within the Region, should independently establish their own standards and database design.

C. Discussion and Recommendation

Option 2 should be selected. The Region should establish a comprehensive database design to be used by all Forests within the Region. Standards for data structure and digitizing procedures should be established. A demonstration project should be conducted to evaluate the preliminary data base design given the full range of expected applications for the GIS. The standards and final database design should be well documented and shared with all Forests within the Region, other Regional Offices and the W.O.

Care should be taken to coordinate with the National Information Requirements project (IRP) which is in the final phase of completion by the WO. Input from Engineering and Management Systems staff as well as other Staff Units should be sought in the process of developing the database. The WO Workload Analysis will also help in guiding the database design.

III. OPTIONS FOR SELECTING AND IMPLEMENTING A GIS

A. Introduction

The options given below for selecting a GIS include only the ARC/INFO system, with various combinations of plans for decentralizing the technology. However, several other GIS systems were empirically evaluated. These included MOSS, INTEGRAPH, SYNERCOM, COMARC, GEOBASED, AGIS/GRAM, Bausch and Lomb, ERDAS, I^2S, and IDIMS. The ARC/INFO system was identified as the best option for possible use at the present time.

ARC/INFO is a proprietory system developed by the Environmental Systems Research Institute, which is used by many state and municipal governments, oil companies, banks, realtors, large merchandising firms, as well as many foreign governments. ARC/INFO technology is fairly new, being only two years old. It includes a fully integrated relational database manager. The data is processed in an arc/node format, rather than in polygon form and operates on Prime and Data General minicomputers. At the present time, ARC/INFO is one of the most technologically advanced of all the GIS systems considered. The analysis capabilities needed by the Forest Service can likely be met by this GIS system. ARC/INFO operates on Data General computers which is compatible with the current Forest Service telecommunications system.

MOSS is the only government supported system, and would not require purchasing software licenses. Also, MOSS is the primary GIS used by Bureau of Land Management, U.S. Fish & Wildlife Service, U.S. Geological Survey and The Bureau of Indian Affairs. There is already a large body of expertise on the MOSS system within the Federal government since these agencies are committed to maintaining the software. Plans are being made to invest several million dollars over the next four years for improvements in MOSS. MOSS operates on Data General minicomputers, and on the DG-20 microcomputer. There are some drawbacks to the system, however. It is basically 8 year old technology, but is being enhanced and upgraded. It does not have a relational database manager to interface tabular data with the map data. It processes data in polygon form which is slow, rather than in an arc/node form which is much faster and less redundant.

The Integraph and Synercom systems both have relational database management systems and process data in an arc/node format. However, neither of these systems operates on Data General computers and would require installation of an entirely new telecommunications system. Integraph is also more expensive than any other GIS. It would require specialized expensive work stations which are only manufactured by the Integraph Corporation.

The following options should be considered for selecting a GIS for implementation in the Region.

B. Options

Option 1:

Maintain status quo with no GIS technology implemented. All mapping procedures would continue as in the past. However, the maps currently being produced should be compiled on standard 1:24,000 scale FS primary series maps which are basically US Geological Survey maps. These should be carefully edited so that when the Region does decide to implement a GIS the maps will be ready for digitizing. Also, developments in GIS technology should be monitored and opportunities for implementation should be considered and reviewed when circumstances change.

Option 2:

Select MOSS. Digitize all data in a standard arc/node format, so that if a more advanced system is implemented in the future, the data would be compatible. Developments in new GIS technology would be monitored and opportunities for using more sophisticated and efficient systems at an affordable price would be considered for possible implementation. MOSS in its present form has several disadvantages and shortcomings. The system is still being periodically changed and improved.

Option 3:

Select both MOSS and ARC/INFO as joint GIS systems. ARC/INFO, would be established at the Regional and Supervisors' office level on a dedicated MV 4000 or 8000 computer. MOSS would be established at the Ranger District level on a microcomputer for small projects and day-to-day work. Procedures would be developed for passing data between the two systems, so that data reformatting is transparent to the user. District Offices would tie into the SO computer by telecommunications.

Option 4:

Select ARC/INFO and install it on a dedicated MV 4000 computer at the SO. Link the Districts and RO to the SO by telecommunications.

C. Discussion and Recommendation

Option 4 should be selected. ARC/INFO is one of the most technologically advanced GIS systems today. It operates on Data General computers; is compatible with the Forest Service telecommunications system; and would satisfy the analysis capabilities that the Region would need.

GIS technology should be decentralized and implemented at the SO and RD levels where the major use of the system will be made. The SO offices should have digitizing capability as soon as possible after implementing GIS technology. A plotting capability (screen dump) is also essential at the time of implementation on the District. A more sophisticated plotting capability should be available at the SO and RO where plot files can be sent, via telecommunications for plotting, but Districts should have their own plotters.

A Forest implementing GIS technology should get one District fully "on line" before proceeding to the next District. There are several reasons for this. First, the utility of the GIS comes from the interaction of the multiple data layers. It is better to have one District with five digitized data themes, rather than five Districts each with only one data theme. Also, it is better to have a full complement of hardware and fully trained staff on one District than a partial set-up and partially trained staff on several Districts.

For the present time, staffing requirements for GIS should not involve hiring any new people at the RO or SO levels except a GIS Specialist in the RO. One person in each SO, which implements GIS technology, should be designated as the specialist concerning GIS related matters. However, this will only involve a reassignment of responsibilities. Two days per week is the best estimate of work load, both at the RD and SO for updating data. While all professional staff will need to be able to use the GIS, this designated individual will need to maintain a higher level of proficiency, and will do most of the digitizing for updating data. The weekly work load may vary for larger than average districts, and the work load may vary with season (e.g. more digitizing may be done in the winter months). In the RO, a Unit's key staff person should be partially dedicated to GIS related activities. A computer specialist from the Management Systems Unit should be assigned half time for software support and telecommunications. A specialist from the Engineering, Geometronics Group should work half time in support of digitizing and plotting capabilities within the Region. A full time GIS specialist should be assigned the duties of training, planning and applications development. (Position responsibilities are given in Appendix I.) A part time GIS Coordinator should oversee the total Region and Forest efforts during the initial implementation phases of the GIS. A GIS Group under the Management Systems Staff Unit should be established as the GIS becomes fully operational in all the Forests, Regionwide. Successful implementation of GIS technology requires a full complement of hardware, software, and technology specialists. This Group could consist of a Group Leader, GIS specialist, computer specialist-programmer, data communications specialist, database management specialist, and cartographic data specialist.

The cost for implementing GIS technology is highly dependent upon a number of factors: the hardware used to operate the GIS software; the GIS software selected; the amount of data to be digitized; and the level of decentralization and the administrative handling of the technology. The personnel time required for preparing maps for digitizing, editing the digitized data, and for training are difficult to estimate. The proposed demonstration project will give much tighter estimates; however, some "ball park" estimates are given in Section IV.

The George Washington N.F. staff has estimated that 12 man years of effort would be required to put the maps on their forest in a form suitable, for digitizing. The cost of digitizing hardware is approximately $10,000. Each RO Unit, RD, and SO that produces data, and wishes to implement GIS technology should have one. Each SO that implements GIS technology should have a computer capability such as a fully equipped DG MV-4000 minicomputer ($78,000). The RD, SO and RO Unit or field office should have a color plotter ($2,000 - $8,000) and a color graphics display terminal ($3000 - $5000). Each Forest that implements GIS would procure the ARC/INFO software. This would cost $35,000 to $75,000 depending upon the economy that might be realized by multiple purchases within the Forest Service. Software is licensed for use on only one machine. Thus, a stand-alone MV-4000 in the SO with one GIS software package could serve all the RD's via telecommunication. Finally, an annual service contract would be required for software license. This could cost $4,000 to $7,000 annually. The cost figures given above are on a per forest, or per system basis. The overall costs for each year can be estimated once decisions are made regarding the plan for decentralizing and the length of the implementation period.

IV. OPTIONS FOR DIGITIZING

A. Introduction

Digitizing the point, line, and polygon data and entering the attribute and tabular data will be the biggest logistical hurdle in the implementation of GIS technology. This will be costly and time-consuming both in the preparation of the maps for digitizing, and in editing the digital data after it's been digitized. However, the massive initial digitizing efforts will be a one-time job. Updating the database must always be done and occasionally new data themes will be added to the database. However, many themes like soils, compartment boundaries, and elevation will change very little over time.

The following options should be considered for digitizing in the GIS:

B. Options

Option 1:

The RO should prepare a Request for Proposal (RFP) and let a contract for digitizing services. This would be a one-year contract, with the maximum level of effort specified. All maps from the Forests or RO Units would be sent to the GIS specialist in the RO, who would serve as contract monitor. He would then check the maps for standards and completeness, prioritize the work and forward the maps to the contractor. The contractor should be required to do the work in the Atlanta area. After the digitizing was completed, the maps and "proof print out" would be returned to the contract monitor for inspection. If the work was completed in an acceptable way, the maps would be returned to the Forest and the contractor would mail a tape with the data on it directly to the Forest or RO Unit.

Option 2:

The RO would prepare sample contracts for digitizing, including the technical specifications and standard data format required. These sample contracts would then be used by the individual Forests or RO Units when contracting for digitizing. The GIS specialist would answer questions and assist the Forests in letting such contracts. He would not be directly involved in inspecting the maps either before or after they were digitized. Each Forest would conform to the database standards and conventions set up by the Region, but would be free to procure as much or as litle digitizing as they had funds to obligate. The themes to be digitized would be left up to the Forest after the minimum number of themes specified by the Region are completed. The GIS specialist would assist the Forests or RO Units in any contract disputes. Under this option, the location of possible contractors could be anywhere.

Option 3:

The Regional Forester and the GIS specialist would specify which Forests and RO Units would have digitizing done each year. Priorities and fairness to all Forests would be considered in the digitizing allocaton similar to the way aerial photography is presently contracted within the Region. All digitizing would be done in the RO with government owned equipment and this would be done by a mix of government and contracted personnel. This would permit tighter control of technical and financial aspects of all digitizing activities.

C. Discussion and Recommendation

Option 2 should be selected. This option gives responsibility and flexibility for digitizing to the Forest Supervisors. Under this option it is difficult to estimate the rate of data capture within the Region. For example, the rate may start out very rapidly just before the next Land Management Plans are prepared.

It is very difficult to estimate the cost for digitizing. The time required varies depending upon the number of polygons per unit area, the line density, (e.g., streams or roads) and the number of points. This will vary by data type and with the Forest. The estimated cost to digitize 20 data themes needed by a Forest on a U. S. Geological Survey 7.5 minute Quad map would be approximately $2,000. Therefore, the $2,000 figure per Quad should be considered adequate. A Forest like the George Washington, which covers all or parts of 99 Quads, the cost for digitizing would be approximately $150,000 to $160,000 because certain quads contain very little Forest-owned land.

Data capture should take place at the organizational level nearest to the user. However, manual digitizing is truly labor intensive. The utilization of automatic (or at least more automatic than manual digitizing) input needs to be fully explored. Existing technology, which has a great deal of merit and potential, is the Line Trace System developed by the Washington Office Geometronics Group and currently residing at the Geometronics Service Center and photogrammetric digitizing. This type of technology offers the opportunity of providing digitial input at a rate many times greater than manual systems.

A mechanism for data exchange between Forests and the RO Units must be established. For example, the Forests need to know when the ownership data, has been updated by the Lands Unit in the RO. Furthermore, each data theme must have an "owner" who is responsible for maintaining quality and supervising the updates. For example, the Forest engineer might be designated as the "owner" of the transportation theme on his Forest. He will need to coordinate on all adjacent districts to assure that the roads "edge match." Each forest supervisor should designate one person on his staff as the Forest's database coordinator. Also the Regional Forester should designate a regionwide database coordinator, who would be the RO GIS specialist.

The Geometronics Group in the RO has two digitizing stations and are currently capturing land status and other themes. This group could be very helpful in preparing base maps and land line status for a GIS. The potential to convert that data to a GIS compatible format needs to be evaluated. The present digitizing capability is outdated and needs to be replaced with state of the art technology.

V. OPTIONS FOR UPDATING THE DATABASE

A. Introduction

Data capture is a continuous task. While the major digitizing effort will be completed in the first year or two after implementing a GIS, substantial annual updating will have to be done. Approximately 10% of all stands and compartments are examined annually. In most cases only the attribute files will need to be changed after a compartment exam. However, a link can be formed between CISC, and the attribute files in the GIS which are updated after each prescription is redone. The update could be accomplished "automatically." Approximately, 40% of the compartments receiving re-examination each year will have changes in stand boundaries, and thus require digitizing. Additional stands will also have boundary changes and require digitizing. Obviously the amount of digitizing will vary with the Forest and with the year. At this time, it is very difficult to estimate cost or work load for updating.

The following options should be considered for updating the database.

B. Options

Option 1:

All maps that need to be redigitized for a District should be sent to the RO where a pool of "expert" technicians will make the necessary changes. This will require that a copy of the original digital data be sent to the RO and the updated version sent back along with a paper "proof sheet" showing the revisions. The field level manager will then check the "paper proof." If the revision was not made correctly, he will note the error on the "paper proof" and mail it, with the digitial data, back to the RO for redigitizing. This process would be continued until the map has been revised correctly.

Option 2:

This option is the same as Option 1 except the maps that need to be redigitized and data updates would be mailed to the SO, where "expert" technician(s) would make the change. Under this option the RO would not be involved.

Option 3:

All digitizing to update the database would be done at the RD by one or more technicians who would be trained to do digitizing. In this option, the resource specialist who indicated the necessary update on the original map could check the technicians's work and would be available to answer any questions as they arise.

C. Discussion and Recommendation

Option 2 should be selected. Options 1 would require mailing data to a distant site for digitizing. Data could be lost, the magnetic tapes might be susceptible to damage from heat, x-rays, or dust; and the staff specialist requesting the update would not be as available on site to resolve questions. The most efficient updating of the database would be at the location where the change is originated. This would primarily be done at the SO. The Forest Pest Management Unit and the Lands and Minerals Unit in the RO will also need their own digitizing capability. This recommendation is also in agreement with that made by the GIS ID Team.

A procedure should be established, that is followed throughout the Region, for periodically archiving the database. This should be done at least once a year. Furthermore, an "automated" procedure should be set up for building an "historical silviculture practices" file on each compartment. A Regionwide standard procedure for this is needed.

VI. OPTIONS FOR TECHNOLOGY TRANSFER AND TRAINING

A. Introduction

GIS is a support technology, just as remote sensing, computer programming, or biometrics, that contemporary foresters need to use in resource management. Universities have recognized this and require students to gain minimal proficiency in each. GIS technology, however, has only recently been added to this list and many seasoned professional foresters are unfamiliar with this technology. Training sessions and awareness programs will be necessary if GIS technology is to be implemented in the Region.

The following options should be considered for technology transfer and training:

B. Options

Option 1:

Arrangements should be made with a corporation or university to provide training on the specific GIS system selected for land managers. This would not require a trainer employed by the government, and should result in a savings to the government. However, the quality and quantity of training would be affected in that everyone who needs the training might not be able to receive it under this option.

Option 2:

When a proprietary system is purchased, the company will provide training as a part of the purchase agreement. Universities and the EROS Data Center are giving 3 to 5-day training sessions on GIS technology. These sessions should be attended by those involved in GIS implementation.

Option 3:

A Forest Service "in house" training capability should be developed in the RO. This capability should reside in the GIS specialist with help from the Management Systems and Engineering staffs.

Option 4:

Combination of Options 2 and 3

C. Discussion and Recommendation

Option 4 should be selected. The level of understanding of GIS technology and support requirements for such is variable, and generally low throughout the Region. New attitudes, skills, and technology must be learned. Awareness training, hands-on experience and demonstrations of GIS characteristics, technology, hardware and software is a necessity to raise the level of understanding, technical skills and knowledge of RO and Forest personnel. To meet this requirement, the GIS specialist should develop training programs and packages and present these to the 15 National Forests and 8 staff Units in the Region during FY 1985-86.

Any GIS system implemented can be expected to be "customized" for specific Forest Service needs. The GIS specialist will need to be familiar with Forest Service management practices and the specific version of the GIS used. Also, the GIS specialist will have to know the data structure and quality and understand its content. The same individual who offers the training should be available for later consultation on the telephone. For all these reasons, an "in house" training capability is recommended.

A two-weeks training course is usually offered when a GIS is installed. This should be done in the field at the location where the individuals in the class will be using the GIS. After the system is installed the GIS specialist should return for approximately five days to work with various land managers individually to assure that all expected users of the system have at least minimum proficiency. The GIS specialist may need to return to field sites to share information on specialized applications. Also, efforts should be made to work closely with one individual in each SO to develop a "local expert." This person will then help new employees become familiar with use of the GIS.

VII. TECHNICAL CONSIDERATIONS

Many technical considerations have surfaced during this evaluation and must be made while planning for implementation of GIS technology. Forests in the Region are distributed over 13 states and Puerto Rico. Many state agencies have GIS systems and therefore, the opportunities for data exchange should be considered. While the BLM/Forest Service land interchanges, involves only limited acres of land in the Region, the responsibility for subsurface minerals on non-public land and the associated digitized data should eventually be transferred from BLM to the Forest Service. The GIS adopted by the Region should be able to read a wide variety of digital data types and minimize the problems associated with reformatting and data exchange.

Updating data......Updating the points, lines and polygons will be a continuous task. Therefore, the ease and efficiency of both tabular and geographic data update should be considered. These tasks could conservatively range from one-half man year to one man year per Forest. The cost savings in labor per year could be very significant if the more efficient systems for update are used. For example, if one GIS system can automatically update the tabular data files as the result of redigitizing changes in stand boundaries, the labor savings might be in the order of 20-50%. Given that the work might be done by a GS-7 technician at an annual salary of $17,138, the savings could be $111,397 per year for the Region.

Relational database management....It is very apparent that a relational data base manager should be part of the GIS. The Forest Service has large amounts of tabular data (e.g., CISC, TIS, LOMS, TIMIS) which must be interfaced with the point, line and polygon data. The tabular data will have to be queried for selected attributes which may not be categorical in nature. For example, a complete paragraph, (i.e., text file) may be required to describe the codicils for a will giving a tract of land to the government. The paragraph must be linked to the polygon and be accessed coincidentally. The ability to mathematically manipulate the tabular data and proportionalize over a portion of a polygon or over several polygons, automatically adjusting the associated tabular file is needed as well as a report writing capability. Many data summaries and analyses which cannot be practically done now should be easy with the GIS. It should be noted that to demonstrate compliance with the Forests' land management plans, such analyses will have to be made routinely. The WO-ID Team recommended that the Forest Service should evaluate the need for GIS's having a relational DBMS to link resource attribute information to spatial location.

The data should be captured and processed in an arc/node structure for many reasons. First, the computer time for processing overlays and other computationally intensive functions can be three to five times faster due to the less redundant topology. Professional staff will likely spend four to six hours per week working interactively on the GIS. This would result in at least one hour labor savings per staff member per week, or essentially one man year (assuming a staff of 40 or more) or $21,006 (for a GS-9) per forest.

The data base management system linkage to a GIS is one of the most important features of a complete cost-effective GIS. Data base management systems (DBMS) currently used by the Forest Service have little or no ability to relate resource information (attributes) to specific geographic locations. Likewise, automated mapping and analysis procedures currently in use in the Forest Service are generally not linked to a DBMS.

Integration of resource attribute information to spatial location via a DBMS, provides a powerful analysis capability. This characteristic of state of the art GIS technology vastly extends the types of applications where GIS's could effectively be used.

Data needs of WO, RO, SO, RD.....The WO supported Workloads Analysis is considering the data needs and the necesssary analysis capabilities from a GIS, but only for the Forests. There are RO needs that must be assessed too. For example, the Lands and Minerals Unit in the RO identified the following data themes as absolutely necessary:

1. Ownership and status of title
2. Tabular file on Land status
3. Minerals
4. Tabular file on Minerals
5. Leases - issued
6. Tabular file on issued leases
7. Leases - pending
8. Tabular file on leases pending

These data were either omitted or given a low priority by the George Washington National Forest which was the only Region 8 Forest participating in the WO Workloads Analysis. Also the financial accounting data for special uses, mineral leases, and payments made to counties should be put into a database management system and linked to the GIS. Furthermore, data on minerals and lease status must be passed back and forth between the Forests and the RO by telecommunications. Some of this data will be updated at the Forest and part will be done in the RO. A plan needs to be developed to accomplish this potentially complex data handling problem. The land status attribute and tabular data needed by the RO may require special analysis capabilities and could influence the selection of a GIS. The GIS Workload Analysis should consider the needs of the Regional and Washington Offices as well as those at the Forest level.

There are opportunities for interfacing within the GIS, the numerous resource databases within the Region. In some cases these databases could be entered into the relational DBMS associated with the GIS. In other cases, links (soft or hard) should be built. A decision will have to be made as to whether to have all the resource databases merged into the GIS itself. A plan needs to be developed for coordinating the various resource databases with the GIS.

Issues for Further Study

This report in only the first step in the implementation of GIS technology in the Region. More detailed evaluations will subsequently be necessary to consider several special technical issues such as:

1. Develop and plan to coordinate and integrate into the GIS the existing resource databases such as CISC, TMIS, TIS, etc.

2. Assess the telecommunications needs to transmit data between the RO, SO, and RD.

3. Develop techniques for quantifying the benefit/cost of a GIS.

4. Conduct a thorough review of all available digital data before new data is digitized.

5. Evaluate the necessity to keep the GIS on a separate computer system from the CEO processing.

6. Develop a comprehensive plan for archiving the GIS database.

7. Develop a data dictionary for the Region's database.

VIII. LIST AND SUMMARY OF RECOMMENDED OPTIONS

A. List of Recommended Options

1. Database design and development

The Region should establish a comprehensive database design to be used by all Forests within the Region. Standards for data structure and digitizing procedures should be established. A demonstration project should be conducted to evaluate the preliminary database design given the full range of expected applications for the GIS. The standards and final database design should be well documented and shared with all Forests within the Regions, other Regional Offices and the WO.

2. Selection and implementing a GIS

Select ARC/INFO as the Region's tentative GIS. ARC/INFO should be established at the SO level on a MV 4000 computer and demonstrate its capability. The Districts would have color graphics terminals and inexpensive plotters and be linked to the SO by the telecommunications system.

3. Digitizing

This option gives responsibility and flexibility for digitizing to the Forest Supervisors. Under this option it is difficult to estimate the rate of data capture within the Region. For example, the rate may start out very rapidly just before the next Land Management Plans are prepared.

4. Updating the Database

All digitizing to update the database would be done at the SO by one or more technicians who would be trained to do digitizing. In this option, the prescriber who indicated the necessary update on the original map could check the technician's work and would be available to answer any questions as they arise.

5. Technology Transfer and Training

Training and awareness sessions for GIS technology should be conducted on 15 National Forests and eight R-8 staff units. When a proprietary system is purchased, the Company will provide training as part of the purchase agreement. An "in house" training capability within the Region should be developed by the GIS specialist with help from other staff units. Personnel involved in GIS should take training made available by universities and the EROS Data Center in GIS technology.

B. Summary of Recommended Options

It is recommended that Region 8 proceed with taking active steps to increase skills and awareness in GIS technology by conducting training and awareness sessions regarding GIS technology. Intensive training on the ARC/INFO system should be provided to the staff of the George Washington, and selected R8 staff units. General awareness sessions on GIS should be held on the other National Forests and staff Units in the RO.

A demonstration project on the George Washington National Forest is of the highest priority and should be immediately implemented . The demonstration project should simulate an actual implementation of a GIS and identify costs, benefits and logistical factors. A comprehensive database design should be established and evaluated as if it was to be used throughout the Region. All maps should be digitized in arc/node format. The work load and logistical feasability of updating the database at the District and SO level should be determined. Finally, the hardware and software needed for the implementation of the demonstration project should be purchased or obligated before September 30, 1985.

IX. PURPOSE AND RECOMMENDATIONS OF THE REGION 8 GIS WORKING GROUP

A. Purpose:

Recent technical developments in Geographic Information Systems (GIS) have created powerful and important tools to support decision making in the Forest Service. The Chief chartered an interdisciplinary team to look at possibilities for implementing GIS in the Forest Service. Recommendations of the team indicate that Regions should take the lead in identifying the functional specifications for the GIS processes and be assigned the responsibility for selecting and implementing GIS technology with the Washington Office providing overall guidance and procedures for identifying and analyzing requirements. It was recommended that the Regional Forester take active steps to 1) broaden the level of understanding in their Regions about GIS technology and 2) raise the level of technical skills related to GIS planning and utilization within their units.

The Region, as a follow up to the W.O. efforts, established a Geographic Information Systems Working Group in February to provide input and recommendations to the Regional Forester. The following individuals were selected to serve on this Working Group:

Bob Phelps, GIS Coordinator, R-8, Work Group Chairman
Roy Mead, GIS Specialist, R-8
Dan Chisholm, Deputy Forest Supervisor, NFs in North Carolina
Larry Grimes, District Ranger, Jefferson NF
George Blomstrom, District Ranger, George Washington NF
Omar D. Smith, Timber Staff, Ozark-St. Francis NF
Bob Bailey, Engineering Unit, NFs in Mississippi
Steve Bailey, District Ranger, Chattahoochee-Oconee NF
Chuck Dull, Forest Pest Management Staff Unit, Doraville Field Office
Lorna Perlman, Lands & Minerals Staff Unit, R-8

The Working Group will play an important role in helping the GIS coordinator in the preparation of a Regional Report and Action Plan which will evaluate existing GIS systems and new technology, determine information needs, develop alternatives and look at ways to implement GIS technology within the Region.

B. Recommendations

A group of eight field level resource managers and RO Staff, who would be eventual users of the GIS, was invited to participate in a two-day meeting in the RO. These people were given several briefings on GIS technology and asked to identify issues which should be considered in planning for GIS implementation. Specifically, in a facilitated discussion, using the Nominal Group Technique, they were asked to respond to the following question: "HOW WOULD YOU LIKE TO SEE GIS TECHNOLOGY IMPLEMENTED IN YOUR UNIT OR FOREST?" Independently, members of the working group prepared responses. These were compiled and duplicate responses eliminated. Then the responses were scored by importance: 10-most important to 1-least important. The ten highest scored responses are given below, and ranked from 1 to 10 in order of importance.

RANK	RESPONSE
1	Need total commitment from Regional Forester recogizing costs and necessary trade-offs.
2.	Need to provide awareness training to users and decision managers to gain their input and commitment before proceeding too far along.
3.	Determine additional hardware and software needs to make operational and determine costs of such equipment.
4.	Cost/Benefits must be considered.
5.	Obtain a cartographic (hard copy) output capability.
6.	GIS should be tailored to field-level needs.
7.	Have whole system, e.g. layers needed thought out before starting.
8.	GIS compatible databases Nationwide if possible, but especially in R-8.
9.	Obtain the best hardware and software available.
10. (tie)	Collection of data would be a joint effort between RO, SO, and RD's.
10. (tie)	Standardized data requirements at the RO level are needed but should be kept at a minimum.
10. (tie)	Review FS GIS compatibility with other Government and private agencies (e.g. USGS Elevation Data).
10. (tie)	Develop GIS and associated database on basis of multiple needs.
10. (tie)	Need for databases should be evaluated with respect to true needs vs. "nice to have."

C. Responses from Group Participants

1. Select 1 or 2 Districts in the Region as Pilots and evaluate any selected system on a llimited basis before implementation Regionwide.

2. Need for data bases should be evaluated with respect to true needs vs. "nice to have."

3. GIS compatible databases nationwide if possible, but especially in R-8.

4. Eliminated.

5. Study to see how GIS systems can be used with existing Data General equipment.

6. Have the entire Region agree to go in the same direction.

7. Eliminated.

8. Defer implementation until FLIPS is fully operational and then evaluate the need for GIS at that time.

9. Cost/Benefits must be considered.

10. Thorough Data-Entry software evaluation.

11. Data equipment and information needs to provide for more detail and displays of project anaylsis and evaluation.

12. Determine additional hardware and software needs to make operational and determine costs of such equipment.

13. Eliminated.

14. Let Forests proceed at own rate within general time frames.

15. Evaluate what capabilities a GIS system will provide to Field Units that are not currently available.

16. Need to provide awareness training to users and decision managers to gain their input and commitment before proceeding too far along.

17. Hardware evaluation based upon selected GIS software.

18. Be able to accept present resource data into a GIS system.

19. Set up Forest Team to determine application of GIS technology.

20. Have Forests maintain their portion of the database.

21. Eliminated.

22. Develop data input (digitizing) skills at all levels in order to reduce the need for contract data gathering.

23. Eliminated.

24. Eliminated.

25. Should be capable of use with short training period.

26. Collection of data would be a joint effort between RO, SO, and RD's.

27. Standardized data requirements at the RO level are needed but should be kept at a minimum.

28. Defer any implementation until available technology improves.

29. Regionwide access to Forest Service data files.

30. Obtain the best hardware and software available.

31. Have whole system, i.e. layers needed thought out before starting.

32. Eliminated.

33. Obtain a cartographic (hard copy) output capability.

34. Need total commitment from Regional Forester recognizing costs and necessary trade-offs.

35. GIS should be tailored to field-level needs.

36. Review FS GIS compatibility with other Government and private agencies (e.g. USGS Elevation Data).

37. Develop GIS and associated database on basis of multiple needs.

38. Eliminated.

39. Limit some data entry to areas where activity is expected to take place within 10 years.

40. Define and organize a Regionwide database.

D. Total Points and Rank Order

Statement Number	Total Points	Rank Order
1.	41	19
2.	52	10(tie)
3.	55	8
4.	Eliminated.	
5.	46	15(tie)
6.	47	14
7.	Eliminated.	
8.	25	23
9.	61	4
10.	51	11(tie)
11.	42	18
12.	64	3
13.	Eliminated.	
14.	46	15(tie)
15.	50	12
16.	65	2
17.	48	13(tie)
18.	48	13(tie)
19.	45	16(tie)
20.	44	17
21.	Eliminated.	
22.	45	16(tie)
23.	Eliminated.	
24.	Eliminated.	
25.	36	21
26.	52	10(tie)
27.	51	10(tie)
28.	24	24
29.	38	20
30.	54	9
31.	57	7
32.	Eliminated.	
33.	60	5
34.	67	1
35.	58	6
36.	52	10(tie)
37.	52	10(tie)
38.	Eliminated.	
39.	30	22
40.	51	11(tie)

X. RECOMMENDED ACTIONS FOR FY 1985 - 86

There are technical, financial and administrative questions which cannot be fully answered at this time. In the short term, the following actions should be taken for FY 1985-1986. Foremost is the implementation of the Demonstration Project to accomplish the 6 stated objectives. Training and awareness sessions for the GIS technology should be conducted on the 15 National Forests and 8 Staff Units within the Region. Specialized training on the use of specific GIS sytems such as ARC/INFO should be received by select Forest and Regional Office Staff who would be involved in the implementation of GIS systems. Finally, a permanent full-time position should be established in the Regional Office for a GIS Specialist.

1. A demonstration project should be conducted which would evaluate ARC/INFO relative to the needed analysis capabilities, benefit/cost and applications anticipated. The project should be large enough in scale to be "realistic" given the magnitude of the eventual effort if a GIS were implemented for the Region. Also, the project should track all costs and labor to give better estimates for Region wide implementation. Considerable effort should be given to quantifying the benefit/cost from a GIS. No decision on selection of a GIS should be done until after the demonstration project the WO workload analysis and benchmarking is completed. A detailed action plan and project description is included in Section XII.

2. Training and awareness sessions for GIS technology should be conducted on 15 National Forests and 8 Staff Units within the Region. This will require preparation of handout materials, examples of computer produced maps, slides, slide tapes, movies, and overheads. A copy of these materials should be shared with other Regions who are involved in similar training activities. Efforts should be made to obtain training materials from universities where courses in GIS technology are taught.

3. A full time permanent staff specialist needs to be hired in the RO if the Region wants to implement GIS technology. Duties of this position are described in Appendix I. In addition, a Computer and Geometronics Specialist on a half time basis should be assigned responsibilities for assisting in GIS implementation, since telecommunications and computer expertise will be required in manipulating the hardware and program software. Another section of this report considers staffing alternatives for support of Region wide GIS implementation after 1985.

4. A GIS "technical steering committee" should be formed. This committee would be composed of the resource user groups of the GIS technology and would address specific technical concerns identified in this report. Members would be selected from the RO, SO and District levels.

XI. ACTION PLANS

The following is a "Proposed plan for implementing a GIS on the George Washington NF and an Action Plan for implementing a Regionwide GIS. It is proposed only as a guide and should be flexible enough to accommodate changes which will be made as new technology as information becomes available in the future.

A. ACTION PLAN FOR IMPLEMENTATION OF A REGIONWIDE GIS

OBJECTIVE: To select and implement a Geographic Information System for use in the U. S. Forest Service, Region 8

Task	Audience	Responsible Persons	Target Date Completed	Estimated Time	Expected Results/Products
Briefing on: -GIS Evaluation Report -Implementation Plan -Demonstration Project	Reg. Forester Dep/Reg. Forester	Roy Mead Bob Phelps GIS Working Group	May 2, 1985	1 day	Question and answers. Make decisions on GIS Implementation and Demonstration Project
Obtain Washington Office approval of Demonstration Project	NA	Regional Forester P&B	June 1, 1985	15 days	Final decision on Demonstration Project
Conduct Demonstration Project	NA	P&B Engineering MS GWNF	June 1,1986	365 days	Technology transfer of alternatives for implementing GIS
Conduct training and awareness briefings on GIS	Regional,Forest District Personnel	P&B Engineering	June 1 thru Dec. 31, 1985	40 days	Technology transfer to Region, Supervisor, District Office staffs - 15 SO offices 8 Regional Units
Prepare written report and briefing on Demonstration Project	Reg. Forester Dep. Reg.Forester Directors For. Supervisors	P&B Engineering MS	July 1, 1986	20-day written report 1-day briefing	Report on Demonstration Project
Prepare sample digitizing contract for use by Forests and Region	Region, Forest staffs	Engineering MS GIS Specialists Procurement Staff	Oct. 1, 1985	14 days	Sample digitizing contract

Update GIS Implementation Plan and briefing	Reg. Forester Dep. Reg.Forester	P&B Working Group	July 1, 1986	7 days updating plan 1 day - briefing	Decision on whether GIS Implementation Plan is on target
Design of data base and plan implementation for George Washington NF	NA	Engineering MS GIS Specialists & SO Staff	Aug. 30, 1986	6 months	Database design and implementation plan
Design of database and plan implementation for Ozark/ St. Francis NF	NA	Engineering MS GIS Specialists & SO Staff	Oct. 1, 1986	6 months	Database design and implementation plan
Prepare FY 1988 Budget request for GIS	NA	Engineering MS P&B & Forests' Staff	Feb. 28, 1986	3 days	Budget request to W. O.
Continue training and awareness briefings on GIS	Forest Staffs in S.O, Districts, R. O.	Engineering GIS Specialists	Jan. thru Dec. 1986		Technology transfer of new GIS technology

Ozark/St. Francis NF and George Washington NF go operational with GIS	NA	Engineering, MS, GIS Specialists, Forests' staff	Jan. 1987 thru July 1987	6 months	First 2 Forests in operational status
Prepare FY 1989 budget request for GIS	NA	Engineering, MS, GIS Specialists Forests' staff	Feb 28, 1987	3 days	Budget request to WO
Design database & plan implementation on 3 additional National Forests	NA	Engineering, MS, GIS Specialists, Forests' staff	July 1987 thru Dec. 1987	6 months	3 Forest implementation plans
The above 3 NF's go operational	NA	Engineering, MS, GIS Specialists, Forests' staff	Jan. 1988 thru July 1988	6 months	3 Forest implementation plans
Prepare FY 1990 budget request for GIS	NA	Engineering, MS, GIS Specialists P&B and Forests' staff	Feb. 28, 1988	3 days	Budget request to W. O.
Design database & plan implemention on 2 additional forests	NA	Engineering, MS, GIS Specialists Forests' staff	July 1988 thru Dec. 1988	6 months	2 Forest implementation plans
The above 2 NF's go operational	NA	Engineering, MS, GIS Specialists & Forests' staffs	Jan 1989 thru July 1989	6 months	2 additional forests in operational status

Prepare FY 1991 budget request for GIS	NA	Engineering, MS, GIS Specialists P&B & Forests' staff	Feb. 28, 1989	3 days	Budget request to W. O.
					operational status
Design database & plan implementation on 3 additional forests	NA	Engineering, MS, GIS Specialists & Forests' staff	July 1989 thru Dec. 1989	6 months	3 Forest implementation plans
The above 3 NF's go operational	NA	Engineering, MS, GIS Specialists & Forests' staff	Jan 1990 thru July 1990	6 months	3 more Forests in operational status
Prepare FY 1992 budget request for GIS	NA	Engineering, MS, GIS Specialists, P&B & Forests' staff	Feb. 28, 1990	3 days	Budget request to W. O. plans
Design database and plan on 3 additional forests	NA	Engineering, MS, GIS Specialists & Forests' staff	July 1990 thru Dec. 1990	6 months	3 Forest implementation plans
The above 3 NF's go operational	NA	Engineering, MS, GIS Specialists & Forests' staff	Jan. 1991 thru July 1991	6 months	3 more Forests in operational status
Prepare FY 1993 budget request for GIS	NA	Engineering, MS, GIS Specialists, P&B and Forests' staff	Feb. 28, 1991	3 days	Budget request to W. O.

Design data base and plan implementation on 4 additional forests	NA	Engineering, MS, GIS Specialists, & Forests' staff	July 1991 thru Dec. 1991	6 months	4 Forest implementation plans
The above 4 NF's go operational	NA	Engineering, MS, GIS Specialists & Forests' staff	Jan. 1992 July 1992	6 months	4 more forests in operational status. All Region 8 operational in GIS
Prepare FY 1994 budget request for GIS	NA	Engineering, MS, GIS Specialists, P&B & Forests' staff	Feb. 28, 1992	3 days	Budget request to W. O.

IMPLEMENTATION PLAN FOR FORESTWIDE APPLICATION

B. There have been several preliminary cost estimates, i.e. hardware, software, database creation etc. of implementing a nationwide GIS which is approximately $50 million. Region 6, using Alternative 3 (planning and project oriented system located at SO and Districts using a minimal dedicated system and a mix of MOSS and commercial software) estimated their costs would be $15.2 million and including F.S. personnel, $26.5 million. Region 10 estimated it would cost $7.6 million for map automation and database creation for the Tongass NF (16.5 million acres). Region 8's demonstration project should give more exact and better cost estimates. The next step after the small scale demonstration is implementation Forestwide.

The following plan is outlined to implement a fully operational GIS on the George Washington N.F. The Forest has a total area of 1.25 milion acres on 6 Ranger Districts. A fully equipped Data General MV 4000 minicomputer dedicated to a GIS located in the SO would be able to handle the ARC/INFO software and complete resource database necessary to operate the GIS Forestwide. The cost would be $18,350./District, $110,100 for 6 Districts and $165,150 for the SO for hardware including the best available peripherals i.e., color graphics display, digitizer/accessories, and 8 pen ink jet plotter on all Districts and in the SO. For another $11,000 each, the RO and WO could be outfitted with an ink jet plotter and color graphics display.

The Forest is on 99 7.5 minute USGS quad maps. The map digitizing and data entry would cost on an average of $2000 per quad for 20 data layers and would be $160,000 since very little Forest land is on some quads. This is a one time cost only. The total cost for such an operational GIS, such as ARC/INFO, would be $457,250 including $160,000 for digitizing and data entry and $22,000 for RO and WO peripherals. If the current CEO system on each District was upgraded including the one-time digitizing and data entry cost and RO/WO peripherals, the toal cost would be $964,000.

The SO would have a Data General MV 4000 with peripherals. Only one license would be necessary for ARC/INFO costing approximately $75,000 with annual support of $7,000. Telecommunication costs would be $16.50/hour connect charge, $600/month usage charge and a one-time $1400 hook-up charge. The Districts would be tied into the SO MV 4000 by the DEPNET telecommuncations network, so data could be transmitted back and forth between the Districts and the SO. The SO could pass data back and forth between the RO. The SO in turn could also pass data back and forth between the WO. All the RO and WO would need are the peripherals to access the GIS maps and database from the George Washington's SO minicomputer. In this scenario the District is linked to the SO who in turn is linked to the RO and the WO. This is the ideal arrangement in which a GIS could be used in a most effective and efficient manner. The plan is practical and feasible to implement in two years if the demonstration can be implemented by October 1985 and the operational by September 1986. The costs for implementing a GIS on the George Washington NF are summarized on the following page.

Cost of implementing a GIS Forestwide

Total Cost for Forest

		Stand Alone GIS System	Upgrading Current FLIPS System on 6 Districts
District Office			
	License	$ 0	$75,000
	Video monitor/keyboard	1,150	1,150
	Color graphics display	3,000	3,000
	Digitizer/accessories	6,200	6,200
	Ink jet plotter	8,000	8,000
	Upgrading current MV 4000	0	37,000
	Total District	$18,350	$130,350
	Total 6 Districts	$110,100	$782,100
Supervisor's Office	License (1)	$ 75,000	
	MV 4000 minicomputer fully equipped	78,000	
	Video monitor/keyboard	1,150	
	Color graphics display	3,000	
	Ink jet plotter	8,000	
	Total Hardware	$165,150	
	Digitizing maps/data entry (one time cost)	$160,000	$160,000
	Total	$325,150	$160,000
Regional Office	Color graphics display	3,000	
	Ink jet plotter	8,000	
	Total	11,000	11,000
Washington Office			
	Color graphics display	3,000	
	Ink jet plotter	8,000	
	Total	$ 11,000	$ 11,000
	Grand Total	$457,250	$964.100

XII. STUDY PLAN FOR DEMONSTRATION PROJECT

A. Introduction

Recent technical developments have created a powerful and important tool to support decision making in the Forest Service. The Geographic Information Systems (GIS) can be used to improve the efficiency and timeliness in arriving at decisions involving complex data. A GIS is an information system with both automatic and non-automated components to store, analyze and display: 1) mapped relationships among and between regimes, 2) quantity and quality descriptions of land and resources, and 3) the interrelationships between mapped information and their descriptions. Some Regions and Forests are already actively exploring implementing the use of GIS technology and the automated GIS processes to support forest resource decisions.

The WO is presently conducting a Workload Analysis and benchmarking tests and is planning a GIS Pilot Procurement and Implementation Project for FY 1986-87. Several GIS systems will be benchmarked and the best ones implemented in a pilot test in several Regions. Results should be available by the end of FY 1987. We maintain that ARC/INFO, MOSS and several other GIS systems have been pilot tested by many others and the results are well known, since they are being used operationally. What we don't know is how these systems will operate within the Forest Service. A demonstration project is necessary to obtain answers to many questions arising from Forest Service applications. A beginning was made with MOSS on the Nicolet NF in Region 9, in Region 6 and Pest Management in Regions 1, 2 and 9. ARC/INFO has never been tried by the Forest Service.

Since ARC/INFO would be a likely candidate for evaluation, Region 8 would like to obtain the system and demonstrate it on a small scale on the George Washington NF. This could be implemented now and completed by June 1986. ESRI has indicated they would furnish us ARC/INFO software, without charge, for demonstration purposes.

The demonstration project outlined below includes a variety of activities designed to acquire further information about ARC/INFO for the Forest Service, which is not presently available. This project will complement the WO Workload Analysis and benchmark tests in progress.

B. Purpose

The purpose of the demonstration project is to gain additional specific information concerning the costs, benefits, logistics, workload, and identify technical problems and transfer of technology with the implementation of a Geographic Information System and its technology within the Forest Service.

C. Objectives

The project objectives are:

1. To determine if ARC/INFO possesses the necessary functional capabilities needed in the Region.

2. To transfer new GIS technology to Regional and field level users through training, hands-on experience and demonstrations.

3. To validate the George Washington NF workload estimates from the WO Workload Analysis and develop benefit/costs for implementing a GIS and its technology.

4. To establish preliminary design for database development, set standards and procedures for data capture and maintenance.

5. To determine the roles and responsibilities of the various administrative levels (RO, SO, RD).

6. To determine if the specific map products and tabular data identified in the WO workload analysis can be produced by ARC/INFO.

D. Project Descriptions

There will be two separate geographic locations involved in the project (i.e., the George Washington NF, Virginia; and Forest Pest Management Field Office, Doraville, Georgia.

1. George Washington NF

A small scale demonstration project using ARC/INFO will be made for the Dry River Ranger District on the George Washington National Forest located near Harrisonburg, Virginia. This project will evaluate the feasibility of transferring technology to the Ranger District and Supervisors Office level, yield benefit/cost estimates, identify training needs and personnel time required. It will also require establishing a preliminary design for a database and set standards and procedures for data capture and maintenance. This will be a joint effort involving the Regional Office, the Supervisors Office and the Ranger District. The project will also consider the costs and benefits to the Forest and assess the expected effort required in table and map preparation, training and the overall improvement in decision making as the result of the improvement in available information.

As the result of the WO Workload Analysis the following map products were identified by the staff of the George Washington National Forest as being of highest priority:

Compartment and Stands
Sensitive Soils
Sensitive Watersheds
Historical Silvicultural Treatment
Visual Quality Objective
Recreation Opportunity Spectrum
Transportation Planning
Timber Sale Plan
Perspective Plot
Wildlife Improvements and Key Areas
Wildlife Timber Coordination
Archeological Predictability
Riparian Areas
Landline Maintenance
Transportation System

Attempts will be made to produce all of these maps and tabular data outputs using ARC/INFO. In addition, functional unit data themes will be developed for Lands and Minerals; Archeology; Pest Management; and Soil, Water & Air; Timber; Engineering and Wildlife. The data themes which will need to be digitized to produce the maps given above are:

Data Theme	Scale	# of Maps
Compartment and Stand Maps	1:15,840	180
Transportation System map	1:24,000	15
Streams and Lakes	1:24,000	15
FS Ownership (Exterior lines)	1:24,000	15
Digital Elevation Model	1:24,000	9 (presently available
Administrative Boundaries	1:24,000	15
Land Management Boundaries	1:24,000	3
Wildlife Habitat Improvements	1:24,000	15
Recreation Site Maps	1:24,000	10
USGS Quad Boundaries	1:24,000	15
Featured Species Map	1:126,720	1
Archeological Sites Map (points)	1:24,000	15
Transportation Analysis Units	1:24,000	15
Utility Corridors Map	1:24,000	10
Forest Soils Map	1:15,840	15
Landline Status Maps	1:24,000	15
Wetlands Maps	1:24,000	2
Floodplains Maps	1:24,000	15
Drainage Basin	1:24,000	15
Response Unit Map Visual Quality	1:24,000	15
Visual Quality Objective Maps	1:24,000	15
Recreation Opportunity Spectrum Maps	1:24,000	15

A detailed action plan for this activity is included at the end of this section of the report.

2. Forest Pest Management

Forest Pest Management has been involved in the development and utilization of GIS to monitor the losses and evaluate forest insect and disease problems in the Southeast for the past five years. FPM's involvement in the demonstration project for the development of a GIS database utilizing a Data General minicomputer would be used for a variety of projects which would include:

a. Develop database to map and assess hardwood mortality on the Dry River RD, George Washington NF using data themes prepared for the RD. Evaluate the trends of this mortality over the past four years and into the future. Also, use the database on the Dry River District to develop hazard rating for forest pests.

b. Develop a database to monitor gypsy moth infestations and for hazard rating on the Dry River RD.

It would be very desirable for FPM to be able to interchange data with other cooperators in this demonstration. Additional Forest Pest Management activities involving the utilization of the Data General minicomputer and peripherals would be included in its on-going program of work and involvement with biological evaluations and insect and disease detection surveys. A detailed action plan for this activity is included at the end of this section of the report.

E. Hardware needs and Costs

The costs for conducting the demonstration project fall into three categories: 1) hardware; 2) contractural services; and 3) travel. The hardware includes a fully equipped Data General MV 4000, digitizer, color graphics terminals and color plotters. These will be funded from the operating budgets of the RO Staff Units and the George Washington NF. Contractural Services will include digitizing maps and data entry for the George Washington NF, to offer training courses and general software support. The third category of costs include travel to the field sites for conducting training and project activities.

Funding for the computer peripherals, digitizing and data entry are already available in the Region, but must be obligated by September 30, 1985. Several RO staff units are contributing funds for digitizing and data entry to make certain their functional needs are included in the data themes. The main funding requirement is the Data General MV 4000 minicomputer which costs approximately $78,000 fully loaded. This computer would be in place in the SO ready to be used for the implementation of a Forestwide GIS. The Region and Forest would have to bear the cost of the minicomputer and peripherals as the WO has indicated no funding for the Regions in GIS would be forthcoming now or in the future. (See section on "Proposed Plan for Implementing a GIS on the George Washington NF.")

ESRI, which is the vendor for ARC/INFO has indicated they are willing to let the Region have its complete software package for one year at no charge.

HARDWARE, PERIPHERAL COSTS FOR DEMONSTRATION PROJECT

Quantity		Forest Service Price after discount
	GEORGE WASHINGTON NATIONAL FOREST	
1	DG 4000/accessories	$78,000.00
2	Tektronix color graphics display	5,998.30
1	Calcomp digitizer/accessories 36 x 48	6,233.00
2	Calcomp plotters 24 x 36	8,010.00
	8 x 11	1,228.15
	Total	$99,469.45
	FOREST PEST MANAGEMENT	
1	Tektronix color graphics display	2,999.15
1	Calcomp digitizer/accessories 36 x 48	6,233.00
1	Zeta plotter 36 x 48 12,255.00	
	Total	$ 21,487.15
	Grand Total	$120,956.60

Total Costs for Demonstration Project

	FY 1985	FY 1986	FY 1987
- Hardware	$120,957[1]	$20,000	$20,000
- Contractural Services	46,000[2]	$30,000	$30,000
- Travel	10,000	$10,000	$10,000
Total	$176,957	$60,000	$60,000

F. Action Plans for the Demonstration Project

1. George Washington National Forest - Virginia
2. Forest Pest Management - Field Office Doraville, Georgia

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[1] Hardware funding by the various units except the MV 4000 ($78,000) is already available for FY 1985 and must be obligated by September 30, 1985.

[2] Costs are primarily for digitizing and data entry for 15 quads, 20 themes, Dry River District, George Washington N.F.

ACTION PLAN FOR GIS DEMONSTRATION PROJECT ON THE GEORGE WASHINGTON NATIONAL FOREST

OBJECTIVE: To determine if the Geographic Information System ARC/INFO possesses the necessary functional capabilities determined in the WO Workload Analysis

Task	Audience	Responsible Persons	Target Date Completed	Estimated Time	Expected Results/Products
Identify data themes to be digitized and set data standards	NA	Forest Staff GIS Specialist	July 1, 1985	30 days	List of maps and and tabular data Data standards prepared
Prepare and edit data & maps for digitizing	NA	Forest Staff	Oct. 1	90 days	Maps prepared for digitizing
Digitize all maps and enter Tabular Data	NA	Contractor	Dec. 1	90 days	Delivery of digitized maps
Train Forest staff on use of ARC/INFO	Forest Staff	ESRI	Jan. 2, 1986	14 days	Transfer Technology to Forest staff
Produce maps and Tabular Products	NA	Engineering MS GIS Specialist	May 1	150 days	Maps and Tables
Prepare report on Pilot Project and give briefings	NA	Engineering MS GIS Specialist	June 1	20 days	Report

ACTION PLAN FOR GIS DEMONSTRATION PROJECT - FOREST PEST MANAGEMENT - DORAVILLE, GEORGIA

Objective: To evaluate and demonstrate the use of a minicomputer in a field office environment for Forest Pest Management Projects, data management and technology transfer of new FPM technology to cooperators.

Task	Audience	Responsible Persons	Target Date Conpleted	Estimated Time	Expected Results
Evaluate hardwood dieback, decline and mortality Dry River RD	George Washington NF State Cooperators in Virginia Forest Pest Pest Management	C. Dull D. Ward B. Uhler B. Clerke	Dec., 1986	270 days	Report timber mortality. Analyze mortality trends over time.
Evaluate gypsy moth aerial survey data for defoliation and hazard rating for gypsy moth.	NFs in Virginia State & Federal Cooperators Forest Pest Management	C. Dull D. Ward B. Uhler B. Clerke	Dec., 1986	270 days	Report results of aerial surveys for defoliation and hazard rate forested areas for future gypsy moth impacts.

Appendix I. Responsibilities of Regional GIS Specialist

The Regional GIS Specialist should have a general background in forestry, resource inventory, remote sensing and GIS technology. The Specialist should possess the necessary statistical, mathematical, and computer skills to effectively operate a GIS system. and should be familiar with the major GIS systems available both in the public and private sectors and have some "hands on" experience with using a GIS. The GIS specialist should possess the necessary writing and speaking skills to train others in the fundamentals and applications of GIS technology and should be familiar with the types of tabular data and maps used in the Forest Service, in addition to having an understanding of Forest Service organization and procedures.

The Specialist would assist Regional Office Directors and Forest Supervisors and their staffs in planning and implementing GIS technology. Responsibilities would include:

---- teaching courses on GIS to Forest Service employees at all levels throughout the Region.

---- preparing reports to the WO concerning GIS activities and accomplishments in the Region;

---- keeping well informed on new developments in software and hardware for use with a GIS;

---- developing new applications of the Region's GIS, both independently and by working with others throughout the Region;

---- assisting Forests in design of data bases as well as in the preparation of contracts for digitizing services;

---- establishing and maintaining standards for data capture and serve as the technical monitor on all digitizing or other GIS related service contracts in the Region;

---- assisting Forests in preparing the specifications for hardware procurements for use with the GIS;

---- assisting Forests in locating other sources of digital map data within the public and private sector;

---- preparing directions (as needed) to assist all Forest Service employees in using the GIS and "mans" a telephone hot line to answer questions about operations of the GIS system(s) used in the Region.